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Implementation of Work Standardization to Improve the Fuel Efficiency Ratio in an SMB in the Hydrocarbon Transportation Sector

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Abstract

In the Peruvian context, the operating costs associated with the transportation of hydrocarbons represent a significant challenge for SMEs in the transportation sector, especially due to high fuel consumption. According to the Ministry of Energy and Mines (Minem,2023), land transportation activity increased by 6.7% in the last year, which highlights the need to implement strategies that optimize distribution efficiency. This research proposes an improvement model based on three key tools: Total Productive Maintenance (TPM), telemetry for efficient fleet management and work standardization, with the objective of reducing fuel consumption and travel time in logistics routes. The methodology applied is descriptive and quantitative, framed in a continuous improvement model. The results obtained validate the effectiveness of the model through simulations and field tests, achieving a 7.7% reduction in fuel consumption per vehicle and a 17.9% reduction in total route time on the Lima - Arequipa route and vice versa. These findings highlight the model's potential to increase the competitiveness and operational sustainability of companies in the sector.

Keywords
TPM, Standardization, Telemetry, Hydrocarbon transportation.

1. Introduction
The land transportation sector in Peru plays a crucial role in the country's economy, being fundamental for the distribution of goods, particularly in the transportation of hydrocarbons. However, it faces significant operational challenges, such as high fuel consumption, lack of standardization in operating processes, and resistance to change on the part of drivers. These problems increase operating costs and affect transportation efficiency, which represents an obstacle to the sustainability of the sector (South Express Cargo, 2023). According to previous studies, road transport, which represents a considerable part of distribution in the country, has costs ranging between 18% and 32% of the total freight cost (Lima Chamber of Commerce, 2022), which makes it urgent to implement improvements in operational efficiency. Despite advances in hydrocarbon production, which increased by 6.7% last year (Ministry of Energy and Mines, 2023), transportation companies still lack systematic solutions that increase their efficiency,

optimize their fuel consumption and travel time. Therefore, this research focuses on proposing an optimization model that integrates the standardization of operational processes, the use of telemetry and the implementation of Total Productive Maintenance (TPM), with the objective of reducing costs and improving the efficiency of transportation companies.

The literature review reveals that several studies have identified that the most common operational problems in the transportation sector are the lack of standardized procedures, poor fleet condition and inadequate driver behavior, which increases fuel consumption and affects the profitability of companies. In this context, research such as that of Durak (2018) stands out, highlighting the importance of understanding the market factors that impact fuel consumption and affect the profitability of companies. This work seeks to extend and apply these solutions in the context of hydrocarbon transportation in Peru, addressing the lack of efficient fleet monitoring and proposing a comprehensive approach to reduce the operating costs of companies in this sector.

1.1 Objectives

The main objective of this research is to propose a model to improve operational efficiency in the transportation of hydrocarbons in Peru. Using process standardization, telemetry and Total Productive Maintenance. The aim is to reduce fuel consumption by optimizing routes and improving operations. In addition, the impact of the standardization of procedures in the reduction of route times and fuel consumption will be evaluated. Finally, we will analyze how telemetry can contribute to real-time monitoring of fleet performance. This study aims to improve sustainability and reduce operating costs in the hydrocarbon transportation sector.

2. Literature Review

2.1 The use of TPM in the hydrocarbon transportation sector.

Total Productive Maintenance (TPM) is a widely used methodology to improve operational efficiency in transportation industries. Its main objective is to maximize equipment availability, reduce unplanned downtime and improve the quality of services through the active participation of the organizational levels (Calderón et al., 2016). In the hydrocarbon transportation sector, the implementation of TPM has proven to be an effective strategy to reduce operating costs by preventing mechanical failures and optimizing vehicle utilization (Perez et al., 2019). A study conducted by Gonzales et al. (2020) in a Peruvian transportation company evidenced an 18% reduction in maintenance costs by implementing a TPM program, which directly contributed to an improvement in operational efficiency. In addition, the TPM methodology favors the standardization of maintenance processes, which optimizes interventions, guarantees the correct operation and performance of assets and reduces downtime, increasing the reliability of the transportation system (Castañeda et al., 2021).

2.2 Telemetry in the hydrocarbon transportation industry

Telemetry has emerged as a crucial tool for monitoring vehicle performance and optimizing efficiency in hydrocarbon transportation. According to Lopez and Rodriguez (2019), telemetry systems enable real-time collection of data on vehicle behavior, including fuel consumption, speed, and geographic location. These systems provide companies with complete visibility into operations and enable informed decision making to reduce operating costs. Research by Martin et al. (2020) shows that the use of telemetry in hydrocarbon transportation can reduce fuel consumption by up to 15% by monitoring and adjusting driving behavior, optimizing routes, and controlling idle time. In addition, telemetry facilitates remote fleet management, which contributes to better resource allocation and faster response to emergencies (Ramirez et al., 2021).

2.3 Standardization of processes in the transportation of hydrocarbons

Process standardization is a key aspect to improve efficiency in the transportation sector. In the context of hydrocarbon transportation, lack of standardization in operations can lead to inconsistencies in fleet management, increasing fuel consumption and downtime (Jarrar and Zairi, 2000). According to Peña et al. (2021), standardization of operating procedures significantly reduces variability in activities, which in turn improves operational efficiency and reduces costs. A study by Garcia et al. (2022) in a Peruvian fuel transportation company showed that the implementation of standardized procedures in route planning and vehicle maintenance resulted in a 12% decrease in route time and a 10% reduction in operating costs. These results highlight the importance of having clear and consistent protocols that guide daily fleet operations to maximize efficiency.

3. Methods

This article is a case study, as it is based on a specific company. In this case, a hydrocarbon transportation company, and a combination of methods is used to analyze and optimize its operations.

The proposed model has as its INPUT variability and inefficient fuel consumption, and the OUTPUT is expected to be a significant reduction in consumption and increased operational efficiency. Thus, the model is structured in three phases: diagnosis, intervention and implementation of improvements, as detailed in Figure 1.

First, an exhaustive diagnosis of the current situation of the fleet and its operation was carried out, with the following steps: analysis of consumption and efficiency indicators (evaluation of the trucks' current performance), Pareto diagram (to identify and prioritize the main causes of high consumption), Ishikawa diagram (to delve into the root causes of the problem), and evaluation of telemetry data (to obtain real-time information on driving behavior and vehicle condition). This allowed us to identify key factors such as lack of process standardization, deficiencies in maintenance, and variability in driver behavior.

Once the problems and their causes were identified, an exhaustive search for applicable solutions was conducted, highlighting process standardization and Total Productive Maintenance (TPM) as key interventions. Unlike models applied in other sectors, the proposed model integrates historical and telemetric data collection with advanced statistical analysis techniques and Machine Learning to identify consumption patterns and areas for improvement. Finally, phase 3 aims to measure the impact of the implemented interventions and compare indicators before and after implementation, ensuring sustainable and continuous improvements in the operation.

Figure 1. Proposed model

4. Data Collection

A total of 21 trucks were analyzed, with manufacturing date as of 2017, selected through a sampling formula and taking into account the technological equipment of the units. The sample focuses on the Lima - Arequipa - Lima route. For this purpose, historical records filed in archives were collected, which include data such as gallons consumed during the trip, mileage traveled, mileage at the time of refueling, gallons refueled according to the tap, vehicle license plate, driver's name, dates of travel and refueling, hour meter, refueling schedules and departure to route. This data was previously recorded manually by the administrative staff and drivers in the supply processes, as well as the maintenance work orders. Additionally, with the implementation of telemetry, real-time data were captured from the platform, allowing for analysis of idling time, fuel consumption, driving behavior, and rest and transit times (Figure 2).

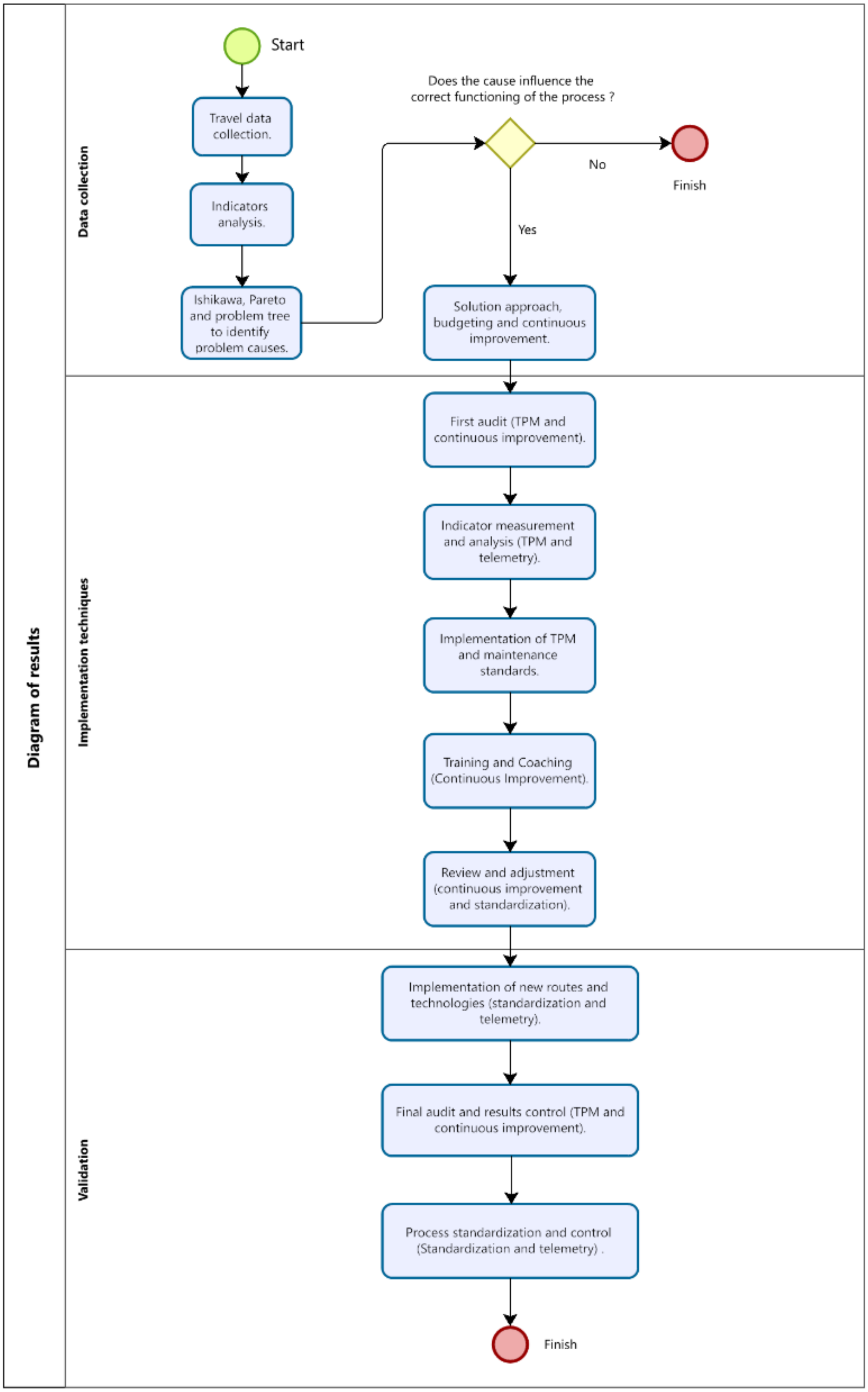

Figure 2. Diagram of results

4.1. Implementation of process standardization, TPM and telemetry

In the case study, the transportation company faces problems related to high fuel consumption and a lack of standardization in its operation and maintenance processes, which negatively impacts efficiency and operating costs. This study focused on a sample of 21 trucks manufactured as of 2017, selected through sampling criteria and technological equipment. The route evaluated comprised the Lima-Arequipa-Lima route, and the data collected included historical information on fuel consumption, mileage, refueling schedules, vehicle license plates, and maintenance records. In addition, telemetry systems were implemented to record in real time data such as idling times, driving patterns, fuel consumption, and rest and transit times.

To identify the main causes of high fuel consumption, analysis tools such as the Pareto diagram, Ishikawa diagram and analysis of variance (ANOVA) were applied. This made it possible to determine that factors such as inefficient route planning, inadequate vehicle maintenance and driving habits have a direct impact on fuel consumption. Based on this information, structured solutions were implemented along two main axes: process standardization and total productive maintenance (TPM). To start the study, times were recorded for all activities that influence time on the road, as well as consumption and number of failures over a period of time, as shown in Table 1.

Table 1. Data and standard activity times prior to implementation

N°	Operations	AS IS	Units	Responsible
1	Time en route	154.85	Hrs	Drivers
2	Fuel consumption	199.65	Gallons	Drivers
3	Idle	4.53	Gallons	Drivers
4	Total Consumption	204.18	Gallons	Drivers
5	Total km traveled	2008	Km	Drivers
6	Performance Ratio	9.83	Km/gl	Drivers
7	Number of failures	20	Failures/year	Mechanics

In this sense, by conducting the relevant studies, it has been obtained that the current standard time for the study route is 6.4 days, with a total of 154.85 hours en route. It was identified that the time of each non-standardized activity significantly influences the increase in travel hours. With this data, we were able to determine key indicators, such as the relatively long time it takes to travel Lima - Arequipa and vice versa. In addition, high fuel consumption associated with drivers' bad habits was observed, among which idling consumption stands out. The latter is mainly caused by prolonged periods of engine idling, practices such as unnecessary starting at stops or breaks, and the lack of proper programming of stops. In addition, it was identified that recurrent mechanical failures in the fleets affect the fluidity of the route, generating significant delays. Once the analysis of the factors mentioned above had been carried out, three selected tools were implemented:

The standardization of processes made it possible to identify critical areas through time analysis, establishing clear procedures and promoting good operating practices (Table 2). On the other hand, total productive maintenance (TPM) focused on optimizing the condition of the vehicles through preventive maintenance, constant revisions through checklists, and driver training to promote greater care in driving and servicing the units. These actions seek to reduce downtime, minimize fuel consumption, and ensure long-term sustainability through continuous improvement.

Table 2. Standard travel times

N°	Operations	AS IS	Units	Responsible
1	Documentation and planning	1.5	Hrs	Logistics Planners
2	Internal transfers	2.2	Hrs	Planning and drivers
3	Fuel supply	0.95	Hrs	Drivers and operators
4	Scheduled breaks and rest	2.5	Hrs	Drivers
5	Contingency management	1.0	Hrs	Drivers, mechanics, administrative staff

The level of success of the interventions was evaluated through key performance indicators, such as reduction in route time, fuel savings and improved operations planning. The implementation of the proposals is expected not only to optimize the company's resources, but also to have a positive impact on the environment by reducing carbon emissions associated with transportation.

- Total fuel consumption: 204.18
- Fuel efficiency: 9.83 km/gl
- Time en route: 154.85 = 6.4 days
- Number of failures: 20 failures / year

5. Results and Discussion

The implementation of the improvements was carried out through a pilot test lasting 8 months, during which all the proposed guidelines and improvements were implemented. During this period, practical Total Productive Maintenance (TPM) techniques were applied, key operating processes were standardized, and telemetry was implemented in the vehicles to optimize fuel efficiency. At the end of the test, significant results were obtained in the indicators of fuel consumption, time on the road and number of failures, which are presented in Table 3. These results allowed the necessary adjustments to be made for future large-scale implementation.

Table 3. Data and standard activity times after implementation

N°	Operations	TO BE	Units	Responsible
1	Time en route	127.2	Hrs	Drivers
2	Fuel consumption	181.3	Gallons	Drivers
3	Idle	3.14	Gallons	Drivers
4	Total Consumption	184.44	Gallons	Drivers
5	Total km traveled	1992	Km	Drivers
6	Performance Ratio	10.8	Km/gl	Drivers
8	Number of failures	7	Failures/year	Mechanics
9	Documentation and planning	1.0	Hrs	Logistics Planners
10	Internal transfers	1.2	Hrs	Planning and drivers
11	Fuel supply	0.5	Hrs	Drivers and operators
12	Scheduled breaks and rest	1.8	Hrs	Drivers
13	Contingency management	0.7	Hrs	Drivers, mechanics, administrative staff

In the To Be model, a significant improvement in operating indicators was evidenced, reducing time on route from 154.85 to 127.2 hours, representing 17.9% less, accompanied by a 7.7% decrease in fuel consumption from 204.18 to 184.44 gallons, thanks to more efficient practices and monitoring.

Likewise, idling consumption went from 4.53 to 3.14 gallons, while annual failures were reduced from 20 to 7, equivalent to 65% less, as a result of efficient predictive maintenance. These improvements reflect greater efficiency, resource savings and operational optimization in the processes evaluated.

Regarding the implementation of telemetry and fleet management systems, the company has followed the essential steps established to optimize its operation and improve fuel efficiency. After conducting a thorough assessment of its needs, appropriate technological solutions were selected, including real-time monitoring, automatic alerts, and advanced data analysis. Training of staff, both drivers and management, has been crucial to ensure effective use of the implemented tools, allowing them to take full advantage of their benefits. Integration with the company's existing systems and customization of the solutions to generate specific reports and alerts have also facilitated a smooth transition. Continuous monitoring of the fleet has allowed us to identify areas for improvement, which has resulted in optimized operations and reduced operating costs. Finally, periodic evaluation of the results has confirmed that the implementation has generated a significant improvement in operational efficiency, reducing fuel consumption and increasing road safety, which contributes to meeting the objectives established in the fleet management strategy (Figure 3).

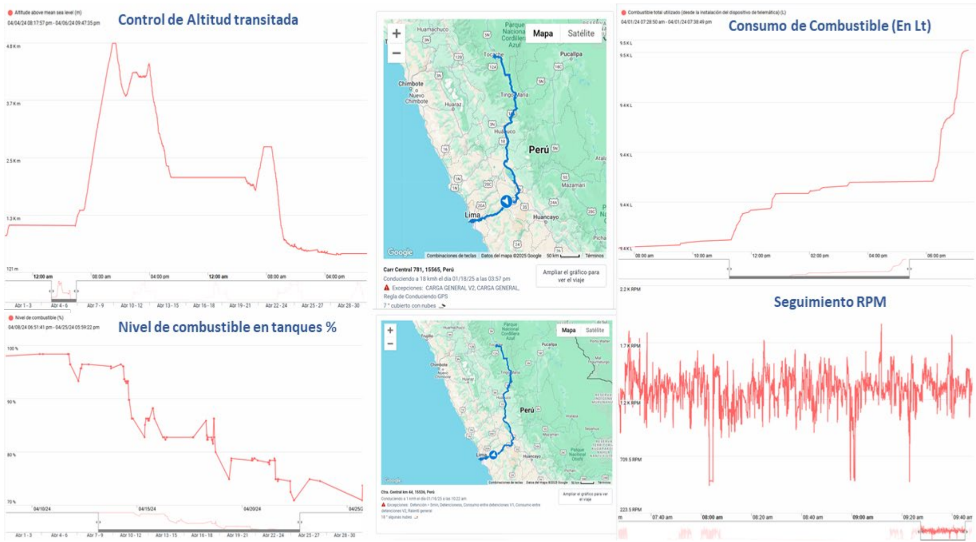

Figure 3. Telemetry platform interface

In addition, the implementation of work standardization has been key to ensuring operational consistency and efficiency across the company. By following a structured methodology, including the creation of a central committee, the design of a standardized system and the implementation of initial and final measurements, the company has been able to optimize key activities such as cargo handling, route planning and fueling. In this context, the transition from manual records to electronic forms has facilitated the accurate capture of data, reducing errors associated with manual entry and improving efficiency in monitoring and decision making. However, process standardization has also faced challenges related to staff resistance to change. To overcome these obstacles, a continuous training approach and a regular feedback system have been implemented, allowing practices and procedures to be adapted to the changing needs of the sector. Standardization has led to significant improvements in operational efficiency, reducing delivery times, optimizing fuel consumption, and raising the quality of customer service (Figure 4).

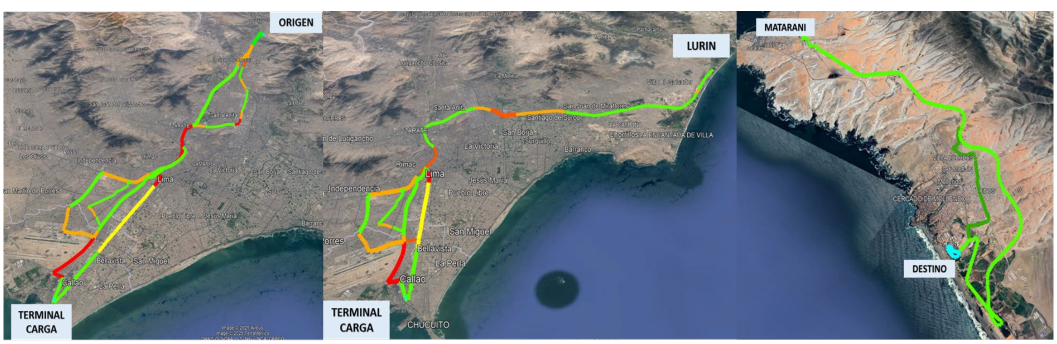

Figure 4. Optimized Roadmap Proposals

Regarding the implementation of the TPM (Total Productive Maintenance) methodology, the fundamental steps of this tool were effectively applied, achieving an improvement in the activities related to the reduction of fuel consumption and the improvement of operational efficiency in the company's trucks. This result reflects significant progress in terms of optimizing fleet maintenance, improving driving habits, and identifying operational losses, such as high fuel consumption. In terms of problem identification, vehicle condition analysis was carried out, including vehicle age, engine condition, routes and driving habits. In addition, ongoing staff training and the implementation of corrective measures such as preventive and predictive maintenance programs have allowed us to optimize the overall performance of the units. As a result, key indicators such as reduced fuel consumption per kilometer traveled, reduced unplanned downtime, and increased efficiency in maintenance interventions have been achieved (Figure 5).

Figure 5. Truck Failures and Defects

5.1 Numerical Results

The following are the indicators obtained after the implementation of the improvements of the pilot test, carried out during 8 months:

- Total fuel consumption: 184.44
- Fuel efficiency: 10.8 km/gl
- Time en route: 127.2 hours = 5..3 days
- Number of failures: 7 failures / year

5.2 Graphical Results

The graphical results after implementation of the tools are presented below in Figure 6, Figure 7 and Figure 8:

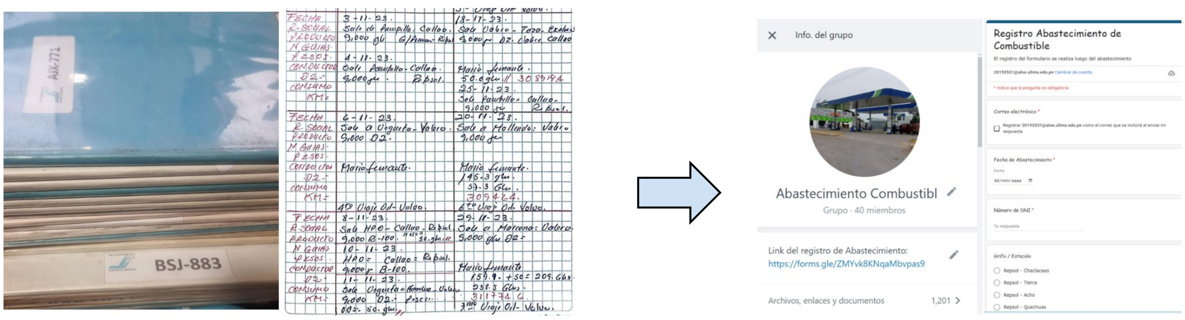

Figure 6. Changes made for work standardization

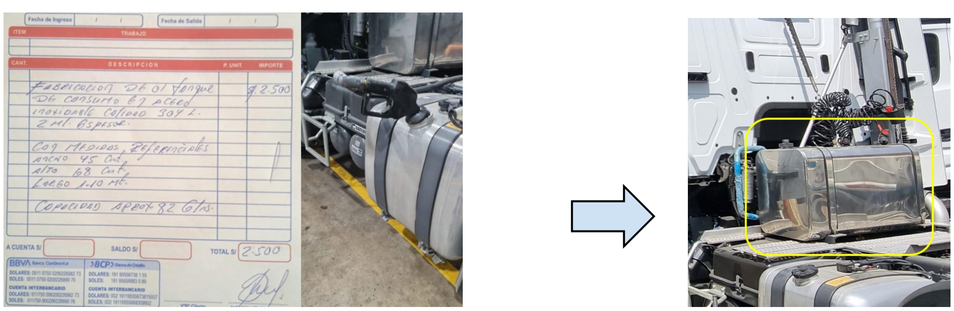

Figure 7. Changes made to vehicles

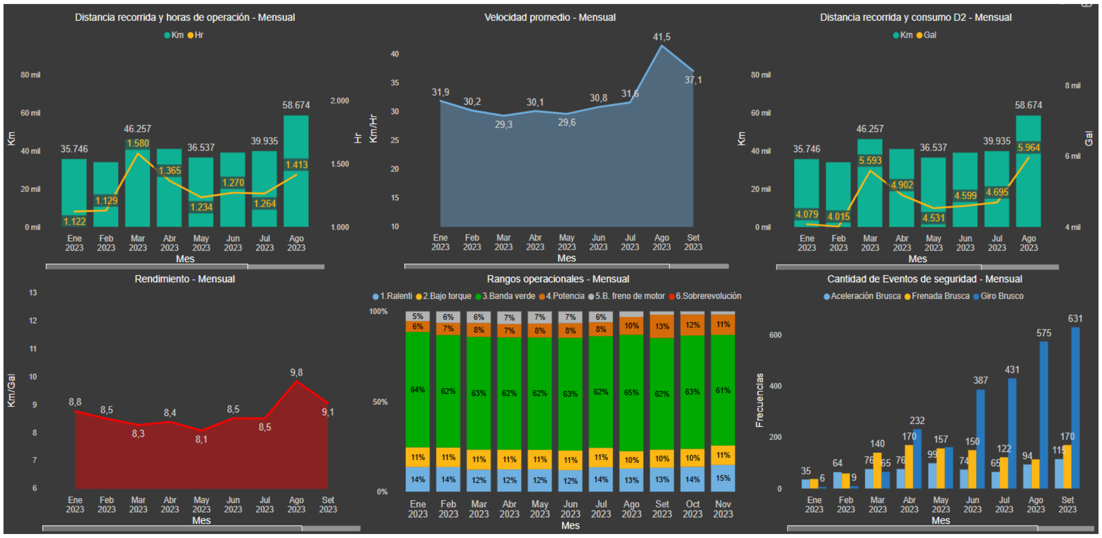

Figure 8. Real-time vehicle and driver monitoring

5.3 Validation

The proposed model was validated through a pilot test and the ARENA simulation application, during which the indicators were recalculated. The comparison and improvement is presented below in Table 4.

Table 4. Comparison of scenarios (AS IS vs TO BE)

Scenario	Time en route	Fuel consumption	Idle	Failure numbers
AS IS	154.85	204.18	4.53	20
TO BE	127.20	184.44	3.14	7
Units	Hrs	Gallons	Gallons	Failures/year

From the final indicators we can conclude that the initially proposed objective was achieved since the indicators showed improvements in the efficiency of performance and above all the order of the processes and if the proposed model continues to be implemented, better results can be obtained.

5.4 Economic Validation

It was decided to evaluate the investment project to establish whether it is viable. The following criteria were used: net present value (NPV), internal rate of return (IRR). For the economic evaluation, a total investment of S/.356,420.00 is required.

The sensitivity analysis allowed us to evaluate the impact of different input variable scenarios on the project's results, specifically on NPV and IRR. The input variables analyzed include the number of trucks, the price of diesel, the cost of initial training and the liters of savings achieved after standardization. The evaluation was carried out through 1,000 simulations for both indicators.

For NPV, the results are positive in all scenarios considered. The average NPV is S/. 416,018, which demonstrates a high probability of economic viability, even under changing conditions. In the case of the IRR, the liters of fuel savings turned out to be the most sensitive variable, having a significant impact on the profitability of the project. The number of trucks and the price of diesel are the second and third most sensitive variables. The average IRR value obtained is 135.5% in the projected yield.

6. Conclusion

With the results obtained, it is concluded that the implementation of the proposed model in the company allowed a significant reduction in fuel consumption and transit times. The standardization of activities during transportation allowed saving 19.74 gallons per trip, which is equivalent to a 9.66% savings in fuel. This value was analyzed according to the volume of trips made per month (4 trips), which demonstrates the efficiency of the model applied.

In addition, by optimizing route planning, transit time was reduced to 127.20 hours per trip. It was also observed that the optimal idling fuel consumption corresponds to 3.14 gallons per trip on the selected route, which contributes to greater operational efficiency.

The economic analysis of the project highlights its high viability, with a positive Net Present Value (NPV) of 416,018 soles and an average Internal Rate of Return (IRR) of 135.5%. These indicators demonstrate that the project is profitable and generates a high rate of return on investment.

The sensitivity analysis identified the number of trucks as one of the most sensitive variables for the economic viability of the project. To ensure a positive NPV and project profitability, a minimum fleet of 15 vehicles is required. This highlights the importance of proper planning and the need to have an adequate fleet to maximize profits.

In summary, the implementation of the improvements has proven to be effective both in terms of operational efficiency and economic profitability, which positions the company in a favorable scenario for its growth and competitiveness in the market.

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